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CASE HISTORIES

*Magnetic
Tape
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It shows how magnetic recorders are solving problems in applications similar to yours.

David R. McClurg

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Staff Editor

Advertising/Sales Promotion

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AMPEX

*Instrumentation
Applications*

**6 MHZ WIDEBAND
RECORDERS FOR RADAR
RECORDING**

CASE HISTORIES

FAA RECORDS RADAR TO TEST AIRCRAFT TARGET AND WEATHER PROCESSING SYSTEMS

The FAA is developing a processing subsystem for radar data to help air traffic control personnel better identify aircraft during storms. Storm signals appear as noise on radar indicators, sometimes making it temporarily difficult to accurately identify and track signals from aircraft. In developing the system, two rotary head wideband recorders (Ampex FR-900 and FR-950) record radar data representing storm signatures and aircraft during different weather environments. In the near future, the program will be expanded to include some six sites around the country. This radar information is replayed as many times as required to set up a standard of comparison and identification in testing system components. Comparison hadn't been possible previously using live radar inputs because the data couldn't be repeated. Both routine and major storms are recorded.



Air Traffic Control Specialist Evaluating the Weather Contours Generated from Recorded Radar Data

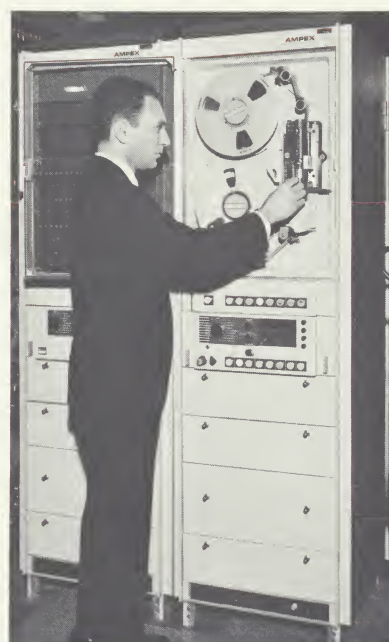
RADAR PROCESSING SUBSYSTEM: Part of National Airspace System

At the National Aviation Facilities Experimental Center of the Federal Aviation Administration in Atlantic City, New Jersey, a program is under way to develop a radar digital processing subsystem for weather and aircraft data. This subsystem is part of the National Airspace System which will provide automated or semiautomated tracking and display of aircraft and radar weather clutter. Within a few years, it will be operational throughout the country to help handle the ever increasing volume of air traffic. Two types of Airspace Systems are being developed: en-route systems with a range of 200 miles, and terminal systems with a range of 60 miles.

One of the principle objectives of the data acquisition program at Atlantic City is to help air traffic control personnel more easily separate aircraft signals from radar weather clutter during all types of weather conditions.

TYPES OF STORMS: Storm Signatures from Common and Infrequent Conditions

Storm data is made up of radar returns from ice and rain in the air. Each storm has a characteristic radar signature



FAA Project Engineer Adjusting the AMPEX Model FR-950 Rotary Head Recorder

which shows direction and indicates approximate intensity in terms of the density of the hydrometeors. Previously, the FAA studied these storm signatures and their effect on aircraft signals in real time on conventional radar indicating devices, such as a plan position indicator (PPI).

Now, the experimental center records radar data during a variety of storms, ranging from common thunder showers to hurricanes, on Ampex FR-900 and FR-950 wideband rotary head instrumentation recorders. Soon, recordings will also be made at major airports to get typical heavy traffic data (such as Chicago, New York, Los Angeles, and San Francisco) plus Norman, Oklahoma, to get typical tornado and land storm data.

Storing the radar data on magnetic tape allows it to be recreated at a later time and studied as many times as necessary to extract all significant information. By this means it is hoped that a standard of comparison and identification can be established between the noise created by storms and the aircraft data. Storage of radar data is especially useful for infrequent storms like hurricanes, since the characteristic signature can be repeated at any time without waiting for another storm to reoccur.

The Center is building up a library of tapes covering all types of weather and signal conditions. Forthcoming field recordings will expand this library and its usefulness greatly. After the development phase, the Center will add new recordings to the library so that it can continuously evaluate and improve the processing system and techniques.

RADAR SIGNALS:

Receiver Output, MTI and Beacon

Several types of radar data are commonly recorded: linear receiver output, logarithmic receiver output, moving target indicator, and beacon or aircraft identification signals. In situations where the Center wants to record more than one type at the same time, the two channel FR-950 is used.

Radar data is presented to the recorder in the form of detected video made up of low frequency clutter blocks and sharp rising pulses. The pulses may have a rise time as fast as 100 nanoseconds, and a repetition rate of up to 1500 pulses per second. The radar triggers are multiplexed as negative spikes while the radar video is positive going pulses. This permits full utilization of each wideband recording channel. During recording, input radar signals are paralleled into a standard PPI scope for monitoring.

To show the position of the radar antenna, output from the positional servo system and an azimuth pulse generator are

multiplexed and recorded on the two auxiliary channels. A time code and voice cueing signal are also recorded on the auxiliary channels to aid in identifying specific activities on the tape.

DATA PROCESSING:

Recorder Recreates Live Data for Repeated Analysis

To process the information, the output of the recorder is treated as if it were a live radar source. Storm data occurs essentially in a random manner with some degree of correlation, in contrast to aircraft signals which occur more uniformly. By statistical analysis of the recorded data, the FAA hopes to set up a data processing program which will allow a computer to suppress a typical storm signal and allow an aircraft signal to be reproduced on the operational displays. The effect on the scope is to remove most conventional weather clutter depending on an adjustable threshold level set into the system by the operator.

However, without the contour of the clutter to identify a storm area, an aircraft could be misdirected into a storm. Therefore, a contour outline of the storm clutter will be derived by the system and presented on the scope along with a visual indication of intensity. This could be shown either by an identifying symbol or the brightness of the contour line. The exact technique is being developed now by repeated replay of the library of radar data on tape. Parallel to this effort, the FAA is digitizing the analog video output for recording on digital tape in IBM compatible format. These tapes will be used in the analytical studies of radar signatures.

ADVANTAGES OF MAGNETIC RECORDING:

Recreating Live Data

Probably the key advantage of magnetic recording in these applications is its ability to recreate the data exactly as it occurred as many times as necessary for complete evaluation of all system components. The FR-900 series records sinusoidal data up to 5.5 megahertz or 6 megahertz with the FR-900A or FR-950 and pulse data with a rise time as fast as 100 nanoseconds.

Related applications of wideband recording are airborne radar recording (using the airborne version of the FR-900 family), predetection recording by feeding the receiver intermediate frequency directly to the recorder, television recording at any scan rate (the recorder is synchronized internally so that it can accept signals of any scan rate singly or in any sequence), and digital recording up to 20 megabits per second and higher.

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CASE HISTORIES

LABEN USES FR-1200 AND TWO TM-7 TO REDUCE ITALIAN SPACE DATA

In Italy, the descendents of Galileo and Schiaparelli are carrying on the rich tradition of advanced research in astronomy and astrophysics. Today, Italy is engaged in several major and a host of smaller space research projects. It has created its own national program, the San Marco Satellite Project. For the multi-national ESRO and ELDO space programs, Italy designs and instruments the satellites. It was among the first nations to cooperate with the United States on several important programs, particularly on communications satellites.

Italian space research is not coordinated by a single agency. Instead, private companies, government agencies, and universities work together in a cooperative effort. In the private sector, LABEN in Milan (Laboratory for Electronics and Nucleonics), supplies on-board and ground PCM telemetry equipment and reduces data from the ELDO program. For its data reduction, LABEN has developed a telemetry processing system using an Ampex FR-1200 recorder and two TM-7 digital tape transports. Final output of the system is a tape containing test data in a computer ready format.

ITALIAN SPACE PROGRAM: National and International

Italy's tradition in space research goes back many centuries: in 1966 the city of Florence celebrated the 500th anniversary of Galileo's birth. While boasting Galileo's genius, Italy also takes pride in the work of other scientists and astronomers. Schiaparelli discovered the "channels" of Mars. Cassini and Fontana first observed the stripes of Venus.

Italian research is now going forward in many areas: satellite design, launching, orbital and re-entry physics, telemetry, balloon flights, weightlessness, celestial mechanics, solar wind and plasma, radio propagation, auto modulation in the ionosphere, communications theory, a joint study with the Mt. Wilson Observatory on solar corona, radio telescopes, and optical tracking of satellites.

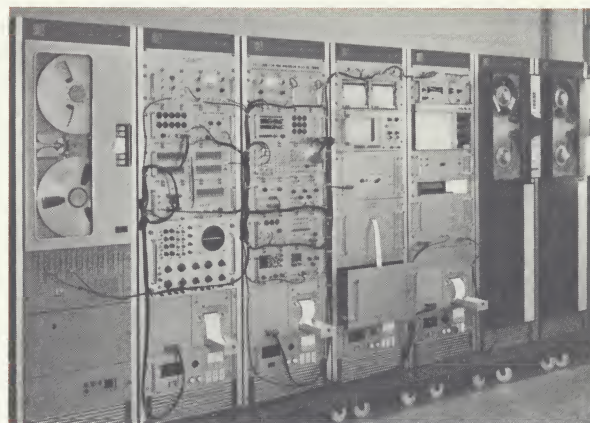
Besides its extensive cooperation in multi-national space programs, Italy has mounted its own San Marco Project, an equatorial orbiting satellite. This ambitious effort is carried on as a joint venture with the United States space agency, NASA, and the Italian Commission for Space Research. Primary scientific mission is a unique method of measuring upper atmosphere density at the edge of space.

San Marco I was successfully launched in 1964, by a NASA trained Italian crew at Wallops Island, Virginia, on a Scout solid propellant rocket. Italy launched San Marco II in April 1967 (again with Italian crews using a Scout vehicle) from a sea platform located off the coast of Kenya. It scored three significant firsts in satellite research: the first equatorial launching, the first equatorial orbit, and the first launching from sea. San Marco C, to be launched from this site in late 1969 or 1970, will carry both Italian and NASA experiments to measure atmospheric density.

ELDO AND ESRO PROGRAMS: Multi-national Cooperation

ELDO, the European Launcher Development Organization, was created in 1962 when seven nations banded together to build a three-stage launcher for heavy satellites. Great Britain is responsible for the first stage, the Blue Streak rocket; France the second stage; and the Federal Republic of Germany the third stage. Belgium supplies the ground facilities; The Netherlands the long-range telemetry; Australia the launching site at Woomera. Italy's role is to build and instrument the satellites and related ground telemetry equipment.

The ELDO launcher (to be operational in 1969) is called Europa I. It will place a satellite weighing about 1320



LABEN PCM Data Reduction System—Model DR1-EL— which uses one Ampex FR-1200 instrumentation recorder and two Ampex TM-7 digital tape memories.

pounds in a circular orbit at an altitude of 344 miles. Being able to launch heavy satellites is important to Europe, particularly in its development program for telecommunications satellites.

ESRO, the European Space Research Organization, was set up by ten countries in 1962; Belgium, Denmark, France, Germany, Italy, The Netherlands, Spain, Sweden, Switzerland, and Great Britain. Italy is contributing scientific instrumentation and participating in work on the first ESRO satellites. Projects include the ESRO I, a polar ionospheric satellite, and ESRO II, an astronomy satellite. ESRO II was fired in May 1967 by a Scout vehicle from the Pacific Missile Range in California, but failed to orbit. ESRO A will go up in 1968. ESRO C (TD-1), a stellar satellite, will be launched by a Thor-Delta rocket. These will be followed by additional scientific satellites.

ELDO DATA: LABEN Telemetry and Reduction Systems

The first phase of the ELDO program is to develop a launch vehicle, launch communications and tracking technology; the second to orbit a satellite. After several static tests, the first test launch was made in May 1966, at the Woomera Test Range in Australia.

This launching was a test of the first stage Blue Streak rocket. The other two stages and the satellite itself were test dummies. In the test satellite (manufactured in Italy) on the first launch LABEN installed a PCM system, Model TL-64, to gain operational experience and test its check-out system, Model DCO-EL. This same check-out system was used on the ESRO II launching.

The next vehicle was static tested in November 1966. LABEN supplied a TL-64 PCM telemetry package, a vibration analyzer, the VA-66, and a check-out system, DCO-EL. Data from the static test was brought to LABEN for initial data analysis. Using an earlier version of its data reduction system, LABEN played these tapes back on an Ampex FR-1200 recorder, then converted the data to punched tapes, a time consuming operation.

For data from the follow-on satellites, LABEN's new reduction system (Model DR1-EL) adds two Ampex TM-7 digital transports which permit simultaneous processing of all parameters. With this system, PCM data is analyzed by playing back the tapes on the FR-1200 through LABEN Signal Conditioning equipment (Model EL135) onto the first TM-7. The serial PCM data and the clock information are recorded together with range timing information which is decoded and converted in BCD format by means of the LABEN Timing Code Translator Model EL235.

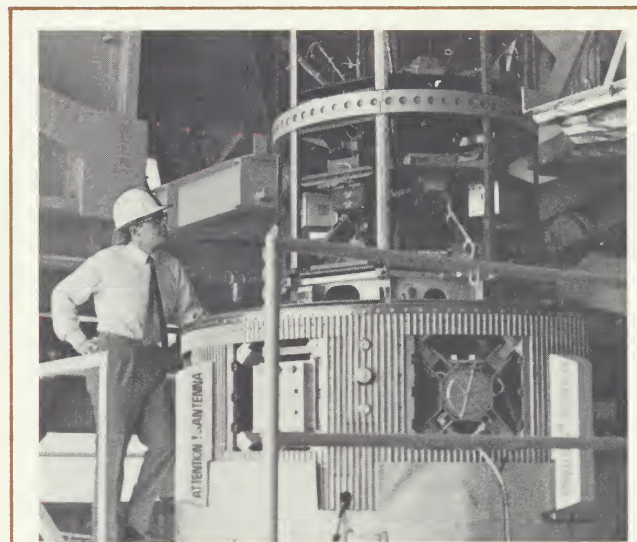
The resulting tape is in a digital format without inter-record gaps in it. Time correlated PCM data can be photographed

for a quick look at this stage. Then it is played back from the first TM-7 through the LABEN Telemetry Processor onto a second TM-7 in computer compatible format. This processing phase is accomplished through a start-stop operation of the two TM-7's, to allow the gapped format tape to be produced without an interposed Telemetry Processor Memory.

Special tape speeds were provided on the TM-7's to allow such a "synchronous production" of a computer compatible tape. It is remarkable that an operative performance of the two TM-7 strictly within the specification characteristic is requested for this synchronous generation mode. The results were completely satisfactory after two data processings.

Preliminary analysis of the data from future tests will be required within two weeks after launch. According to the Data Reduction team at LABEN, "Magnetic tape recording, analog and digital conversion, and digital recording in computer format permit us to meet this schedule. On future orbital flights the increasing quantity of data involved will be handled by the higher performance and the greater flexibility offered by the new LABEN PCM Data Reduction System (Model DR2-EL) now under development. This new system includes a LABEN 4096x24 Magnetic Core Memory System in its Telemetry Processor."

As in several other European countries, Italy's LABEN has been able to look ahead and use some state-of-the-art developments in electronics and space technology. In the PCM Telemetry supplied for the second launch, the Model TL-66, conventional printed circuit boards are used in the analog section, but integrated circuits are used in the digital section. Latest LABEN PCM electronics, Model ML-67, uses integrated circuitry throughout.



The Satellite of the ELDO Europa I Vehicle with two LABEN Vibration Analyzers.

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